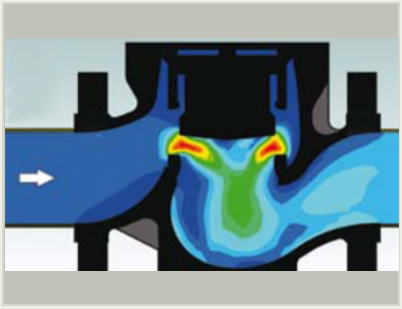
# Robust Cryogenic Cavitation Modeling for Propulsion Systems Ground Test Facilities, Phase I

Completed Technology Project (2016 - 2016)

## Project Introduction

Rigorous ground testing mitigates space propulsion system risk by enabling advanced component and system level rocket propulsion development and by demonstrating that designs reliably meet the specified requirements over the operational envelope before the first flight. The development of advanced ground test technology components and systems that are capable of enhancing environment simulation, minimizing program test time, cost and risk and meeting environmental and safety regulations is focused on near-term products that augment existing state-of-the-art propulsion system test facilities. Thus improved capabilities to model and predict component behavior in harsh ground test environments are needed for enhanced facility design. In particular, components such as valves, check valves and chokes that are subjected to high pressure, high flow rate cryogenic environments will experience potentially damaging two phase flow effects such as cavitation. Robust cryogenic cavitation models for real fluids equations of state in the presence of mixed supersonic/subsonic flows are demonstrated to deal with poor solution convergence and numerical instabilities. The proposed innovation leverages modifications to the local preconditioning formulation of the Roe flux with a barotropic equation of state and uses a representative component flow problem to demonstrate the effectiveness of enhanced modifications to the cryogenic liquid tabular equation of state. Instabilities arising from the single temperature assumption in the two phase mixture equation of state, which must often be evaluated by extrapolating data too far from the saturation curve, are eliminated with a nonlinear temperature limiter that precludes non-physical behavior, such as imaginary mixture sound speeds. The result is an efficient, robust cryogenic cavitation model suitable for application to propulsion systems ground test facility component design and analysis efforts.



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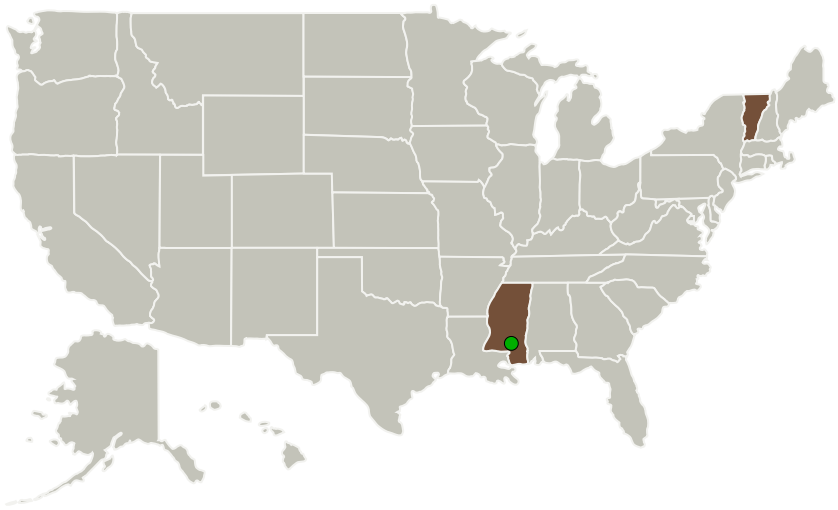
## Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| Tetra Research Corporation | Lead Organization | Industry<br>Women-Owned Small Business (WOSB) | Princeton, Illinois |
| Stennis Space Center(SSC) | Supporting Organization | NASA Center | Stennis Space Center, Mississippi |

| Primary U.S. Work Locations | |
|---|---|
| Mississippi | Vermont |

## Project Transitions

**June 2016:** Project Start

**December 2016:** Closed out

**Closeout Documentation:**

- Final Summary Chart*(https://techport.nasa.gov/file/140355)*

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

Tetra Research Corporation

**Responsible Program:**

Small Business Innovation Research/Small Business Tech Transfer

## Project Management

**Program Director:**

Jason L Kessler

**Program Manager:**

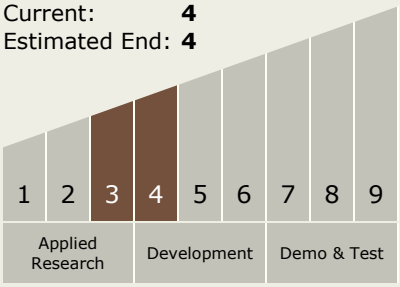
Carlos Torrez

**Principal Investigator:**

Robert R Chamberlain

## Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



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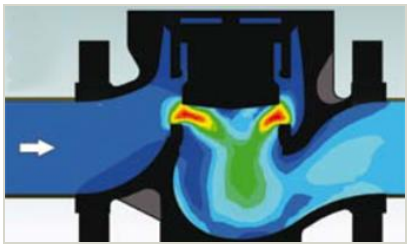
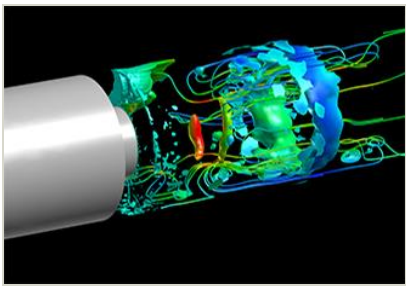
## Images



**Briefing Chart Image**
Robust Cryogenic Cavitation Modeling for Propulsion Systems Ground Test Facilities, Phase I
*(https://techport.nasa.gov/image/130810)*



**Final Summary Chart Image**
Robust Cryogenic Cavitation Modeling for Propulsion Systems Ground Test Facilities, Phase I Project Image
*(https://techport.nasa.gov/image/129046)*

## Technology Areas

**Primary:**

- TX11 Software, Modeling, Simulation, and Information Processing
  - TX11.2 Modeling
    - TX11.2.4 Science Modeling

## Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System